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# A TECHNICAL SERVICES REPORT (SW-6TS) COMPREHENSIVE SOLID WASTE STUDY JOHNSON CITY, TENNESSEE

NATIONAL CENTER FOR URBAN AND
INDUSTRIAL HEALTH, CINCINNATI, OHIO

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TECHNICAL SERVICES REPORT (SW-6ts)

COMPREHENSIVE SOLID WASTE STUDY

JOHNSON CITY, TENNESSEE

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
NATIONAL CENTER FOR URBAN AND INDUSTRIAL HEALTH
Solid Wastes Program
Cincinnati
May 1968

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## SUMMARY AND RECOMMENDATIONS

The solid waste handling system of Johnson City is clean and well equipped. Collectors are thorough and their service is adequate. It appeared, however, that the system is over-equipped and engaged in some uneconomical practices that are apparently caused by the absence of operations records and slow evolution of the system without cost-saving innovations.

The findings suggest that (1) collection routes be more carefully controlled, (2) a new system of handling bulk containers be inaugurated, (3) direct haul to the disposal site replace a portion of the transfer operations, and (4) twice-weekly collection replace container spraying for fly control.

Changes are suggested in the ordinances covering solid waste handling. The major changes needed would assign resposibility for collection and disposal to a single city official and would define forms of service to individual homeowners. Further regulation of hospital waste handling and landfill operations is advised.

The detailed analysis of the nature of the solid wastes of Johnson City was made primarily to aid research at the U.S. Public Health Service--Tennessee Valley Authority Composting Plant. It was found that on the average each person disposes of 1.1 pounds of solid waste daily* and that this is nearly equaled by his share of the community's commercial wastes. These wastes contain a slightly higher fraction of food wastes than anticipated, amounting to 26 percent by weight. No significant solid wastes high in nitrogen content were found other than wastes from residential and commercial sources.

It is suggested that the City engage a competent consulting engineer to further study the system and to develop detailed plans for implementation of the findings of this report.

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*This is lower than the National average per capita figure possibly because some wastes are salvaged, some burned in backyards, and others are collected privately.

# INTRODUCTION

In October, 1965, Congress passed the Solid Waste Disposal Act (PL 89-272) charging the Secretary of the Department of Health, Education, and Welfare to initiate a Federal program in solid waste management. Sec. 202(b) (2) defined the purpose of the Act "To provide technical... assistance to state and local governments and interstate agencies in planning, development, and conduct of solid waste disposal programs."

At the request of the officials of Johnson City, Tennessee, and the Joint U.S. Public Health Service--Tennessee Valley Authority Composting Project, Technical Services and other elements of the Solid Wastes Program conducted a study of the solid waste management system of Johnson City. Johnson City is an active partner with the Public Health Service and the Tennessee Valley Authority in conducting composting operations and the City's participation is vital. The study was intended to aid in improving the system's operation and to aid the City in its continued participation in the project for the years to come.

The study was conducted in October 1967. The current efficiency of the system was evaluated and features noted that may need particular attention during its future growth. Johnson City's solid wastes were also analyzed to aid research activities at the compost plant. The study lasted one week. Data collected during that week were supplemented by prior information on the system gained from personnel of the composting plant, former reports on the system by the City and advanced information provided by City officials. The data are, however, considered limited due to the short period of the study, and should be resubstantiated before the recommendations based on it are fully implemented.

# PROCEDURE

This report describes the solid waste management system of Johnson City, Tennessee, and is based on information gathered during a five-day study, conducted by Technical Services, Solid Wastes Program, and the City prior to the study. The study was planned during September, 1967, and conducted during the week of October 16 to 20, 1967. During the five-day study, members of the study team followed the schedule described in Appendix F-I.

Preliminary information on the quantities and nature of hospital wastes handled by City collection forces was gathered by personnel of the Public Health Service--Tennessee Valley Authority Composting Plant during the month of September, 1967. All hospitals were surveyed to determine the disposal techniques for pathogenic wastes. Information useful to the study collected during this survey included an estimate of waste composition and quantity as well as its collection frequency. The form on which this data was collected is reproduced in Appendix F-II.

A survey conducted by the National Communicable Disease Center, Atlanta, Georgia, in August, 1967, established that the incoming solid wastes was the primary source of fly larvae at the plant. This information led the study team to concentrate on determining the cause of fly production in the City. This was done by observing evidence of fly breeding in and under residential solid waste storage containers.

Data on solid waste handling, compiled by the City prior to this study, included maps, ordinances, and a report on the system by the former City Engineer.

Maps of collection routes were used to establish the number of services on each route. Another map provided by the City Planning Office showed average family incomes for various neighborhoods of the City. This was used, along with the collection route map in selecting areas for the special collection of solid wastes which were physically separated.

Johnson City's ordinances governing solid waste handling are discussed on page 31 of the report. Suggested changes in the ordinances are proposed in the body of the report.

The City also provided a 1966 report on the activities of the solid waste collection force by the former City Engineer. The report, and a portion of the time study data that substantiated its findings were valuable in establishing the nature and extent of special services and in determining which businesses required above average collection times.

A study of the industrial and commercial sectors was conducted by interview with establishments receiving city collection service. Waste generation rates and waste composition were noted from truck weights and visual observation when collection trucks unloaded at the transfer station.

During the study, quantities of commercial solid wastes were obtained by weighing the city trucks servicing commercial establishments. Certain trucks did not collect commercial wastes entirely. The percent of the commercial solid waste collected by these trucks was estimated by the drivers and the superintendent.

City compactor trucks were weighed on Monday, Tuesday, Thursday, and Friday of the study week (October 16, 17, 19, 20, 1967). Trucks hauling bulk containers from commercial establishments were weighed on Monday and Tuesday (October 16, 17, 1967). The volumes of waste arriving in all bulk containers were estimated by noting the container capacity and percent full. The weights of the contents of the unweighed containers received on Thursday and Friday were estimated using the densities estimated on the first two days of the study.

Twenty large commercial establishments were interviewed. They were selected for study based on their size or data from the 1966 City Engineer's report which indicated that the time required to collect their solid wastes was great. The interviews were conducted using the form in Appendix F-III. The adequacy and frequency of the service, as well as methods of private disposal or salvage were surveyed.

Information on industrial wastes came primarily from interviewing 32 of the largest industries in Johnson City. Very little industrial waste is collected by city forces. For this reason, it was not possible to weigh industrial solid wastes and estimates of their quantity came primarily from interviews. These interviews also helped estimate composition and practices of salvaging and disposing these wastes. This information was compiled using the form found in Appendix F-IV.

Quantities of residential solid wastes were obtained by weighing truck loads on four days of the study. On the fifth day, a special collection in the areas previously described provided solid wastes for separation into physical categories, as described in Appendix "C". Information on composition will be used to aid research at the composting plant.

Interviews were conducted at all clinics and small medical centers to determine waste characteristics, quantities generated, and disposal techniques employed. This was done to augment the previous study on hospital wastes. The interview form used is in Appendix F-V.

The study team inspected all sites at which Johnson City solid wastes are disposed. These sites included the Cash Hollow Dump, the Chilhowie disposal site, and the private dump near Jonesboro. Determinations were made of the standards of these operations.

Information on the activities of the single private collector in the area, the Washington County Utility District, was obtained through its records which were made available to the study team. These records afforded a good picture of the routing and services provided by the District.

Areas contemplated for annexation by the City were surveyed by automobile to get an accurate picture of their stage of development and to count the number of homes and businesses which will require service. Other features that might pose special collection and disposal problems were also noted.

# CURRENT SOLID WASTE HANDLING SYSTEM

Nearly all solid wastes in Johnson City are collected by city forces at regular intervals and are taken to the city's transfer station where they are routed to either the compost plant or the city dump. Solid wastes are collected by both the Sanitation Department and the Street Department. The Sanitation Department is responsible for commercial and residential wastes while the Street Department collects leaves and brush and is responsible for snow removal, street sweeping and storm sewer cleaning.

## Storage

Only the Sanitation Department is concerned with wastes which require storage prior to collection. Residential and commercial sources contribute the majority of the city-collected solid wastes. Since these wastes may be stored for as long as a week prior to collection, the condition of the storage containers is important because proper storage is one of the first steps in securing vector control and elimination of community health hazards.

Residential solid waste storage in Johnson City is generally good. Cans are covered and shielded by protective racks which ward off animals and alley traffic. Covers are usually carefully replaced by the collector after the cans are emptied; a consideration ignored in many cities.

There were instances of deteriorated racks and containers as well as overflowing containers. In the cases noted, collectors inverted rusted containers to call their condition to the attention of the homeowner. Collectors, however, have made no attempt to inform the supervisor or to confiscate containers as authorized in Section 14-5 of the Ordinances of Johnson City. Both deteriorated and overflowing containers create ideal conditions where flies and rodents can feed and propogate. Such conditions present a hazard to public health and increase collection costs.

## Collection

Solid wastes ir Johnson City are collected by a variety of methods. Residential and some commercial wastes are collected by city and private compactor trucks while wastes from some industries and large commercial establishments are collected by special city crews and equipment.

Residential wastes and 40 percent by weight of the commercial wastes are collected weekly by 5 three-man crews with compactor trucks. These crews are assigned weekly "large routes" broken down into daily routes which have indefinite finishing points. The result is that residences near one end or another of a daily route may wait an extra day for service or receive service a day early, depending on the progress of the crews.

Collection in the city's alleys is most convenient and efficient because it provides easy access to great numbers of residences with minimum time and effort. It is also convenient for the homeowner who is not expected to set cans at curbside on a specific collection day. This is particularly important since truck crews operate on weekly rather than on strict daily schedules.

The situation is not as convenient for those homeowners who are expected to set cans at specific accessible points (usually at the curb) on collection day. The inconvenience of having to move cans to and from the collection point is compounded when collection days are indefinite. This problem has been eliminated by some homeowners who store their containers at curbside.

Approximately 9 percent of the residences receive the special service of having containers carried from and returned to their backyards. In some cases trucks are backed into driveways to service the containers. This service is found most frequently in higher income neighborhoods but is not restricted to them. Special services are not restricted to contiguous neighborhoods. Many instances were noted of backyard services spotted between alley and curbside services along the same street.

About 10 percent of the homeowners in Johnson City, however, burn some wastes in their backyards. The resulting volume reduction allows them to get by with the limited number of cans their racks will hold. Others employ private collectors to provide supplemental service once a week. To receive twice-weekly collection, 130 homeowners pay extra monthly fees to private collectors. The municipal collection service to these segments of the population were judged to be inadequate.

## Municipal Wastes

The City itself contributes wastes which are collected primarily by the Street Department. Leaves are collected from street gutters by 2 trucks equipped with suction systems. During the fall 2 three-man crews (each composed of a driver and two rakers) are employed at these tasks. The trucks are each filled about twice daily and deposit their 14-cubic-yard loads at the city

dump, in private gardens, or on the old Chilhowie disposal site. Eight cubic yards of street sweepings are deposited daily at the Chilhowie disposal site from the city's street sweepers.

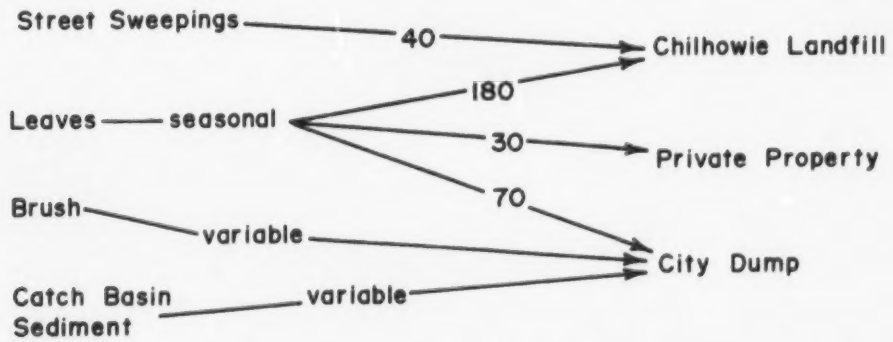


Figure 1

WASTES COLLECTED BY THE STREET DEPARTMENT IN CUBIC YARDS PER WEEK

No wastes collected by the Street Department are transferred through the Sanitation Department's transfer station because the City fears that the abrasive nature of the wastes might harm the runners of the packing mechanism in the transfer van.

## Industrial Wastes

Industries in Johnson City generate 130 tons of solid waste weekly. The majority of the wastes are hauled to disposal by employees of the industries themselves (Figure 2). Large quantities of cardboard and metals are salvaged for reuse in other processes. The Sanitation Department collects from 7 industries accounting for approximately 9 tons per week.

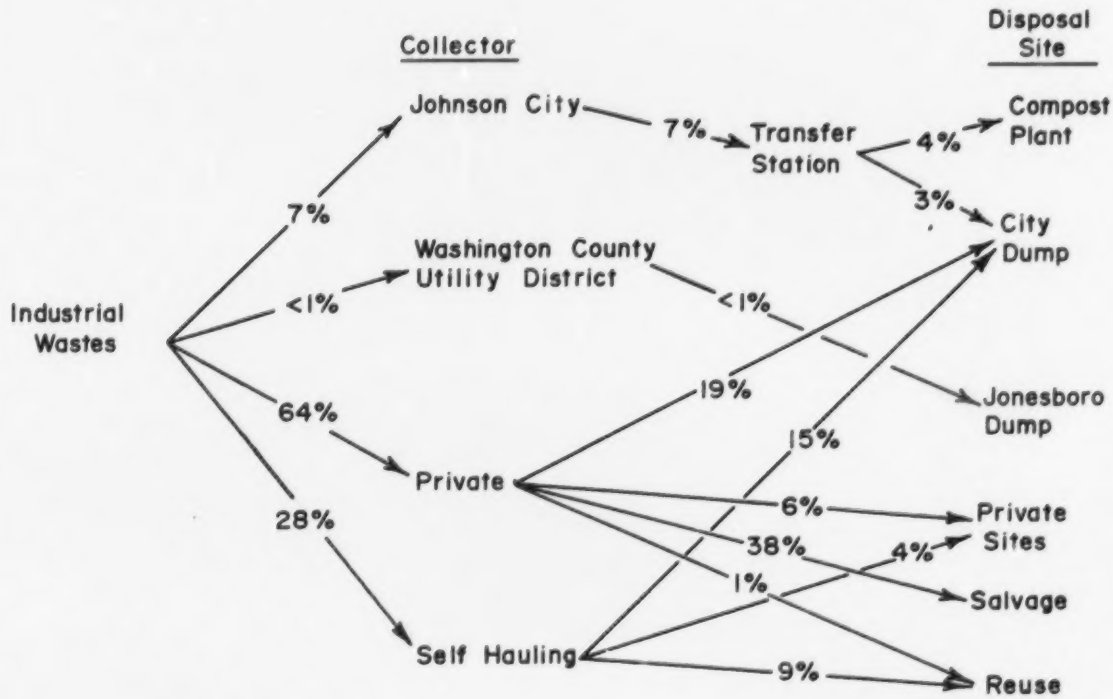


Figure 2

DISPOSAL OF 130 TONS OF INDUSTRIAL WASTES WEEKLY

## Transfer and Disposal of Solid Wastes

All solid wastes (with the exception of brush) collected by the Sanitation Department are hauled by collection trucks to the transfer station adjacent to the city garage. Wastes are hauled from the transfer station to either the compost plant or the city dump. The City uses 2 compactor transfer trailers for this purpose. The trailers have a combined capacity of 118 compacted cubic yards and each makes 2 trips a day to the disposal sites.

The compost plant accepts that portion (50 to 75%) of Johnson City's solid wastes that it can effectively process. The remainder of the wastes are transferred to the city dump.

The city dump receives 35 tons of residential, commercial, and industrial wastes daily. Sawdust, leaves, and brush are segregated and burned separately. The disposal area receives some final, but no daily or intermediate, cover. Its standards of operation are below those advocated by the U. S. Public Health Service and the State of Tennessee. In order to upgrade the operation the City must cease burning, compact, and cover the wastes daily.

## Private Collection and Disposal

Private collection in and around Johnson City is conducted by the Washington County Utility District, a private firm. This company serves 130 homes within the City and about 900 in adjacent areas. Neighborhoods in these areas receive collection coverage ranging from 20 to 90 percent.

Collected solid wastes are dumped at a site shared with the City of Jonesboro, Tennessee. Although more attention is paid to earth cover and housekeeping, this site was considered equal to the Johnson City dump. It is not a sanitary landfill. Records of routing and the number of customers served by collection crews were readily available from the Washington County Utility District.

# ANALYSIS OF CURRENT SYSTEM

It cannot usually be said that the solid waste handling system of any city is uniformly adequate or inadequate. Instead, the various facets of a system must be analyzed and compared to ideal standards. The present analysis considers the adequacy of collection and vector control services, and describes how the costs of the system should be allocated to the sectors (residential, commercial, industrial...) requiring service. It reports on the efficiencies of the collectors, equipment, and methods employed as well as the acceptability of the disposal techniques. Finally, it analyzes the ordinances pertaining to solid wastes handling in Johnson City.

## Storage and Fly Spraying

The storage of solid wastes in Johnson City was generally good but there was evidence that it is inadequate to control flies. Fly larva are carried to the compost plant and the city dump in the collected waste, where they mature to become a severe nuisance. Cool weather prior to the study hindered intensive survey of the fly problem by depressing the fly population. Nevertheless, evidence of it was still present in the form of pupae discovered by surveyors in some garbage cans.

To establish the extent of fly breeding in storage containers, another, more intensive study during the summer months is needed. Technical Services is prepared to make such a study if desired by the City and the compost plant.

Flies are recognized mechanical vectors of disease. They have been known to carry organisms which cause typhoid, dysentery, pin worms, tape worms, conjunctivitis, anthrax, and other diseases. Other studies[1] have been conducted under conditions not identical to those found in Johnson City, but they lead us to believe that during the summer months an average of 700 larva migrate from each storage container each week.

Attempts by the City to restrict fly breeding in solid wastes storage containers have consisted of policing the containers as mentioned earlier and residual spraying at intervals with a moderate dose of an organophosphorus insecticide, Malathion®.

It is felt that adequately policed storage is an essential part of any solid waste handling system but that container spraying for fly control provides only short-term abatement. Homeowners who periodically rinse cans to avoid odors also rinse out insecticide residuals.

The City spends between $8,000 and $10,000 per year based on 1966 and 1967 budget figures for container fly spraying.

The most effective fly production control is to collect solid wastes at least twice weekly. This removes food and breeding media before the cycle of fly reproduction is completed. Collection at least twice weekly in Johnson City would also reduce the need for most open burning and some collections which are now specially scheduled. The City now spends $65,400 annually for collection of residential solid wastes. Should the City collect more frequently there would be fewer cans at each home, collectors would work faster, and daily routes would lengthen. The more frequent service will prompt greater quantities of wastes due to decreased reliance on private collectors and open burning, but because the crews are faster, the cost of service will increase only about 80 percent.

## Residential Collection

Residential solid waste collection in Johnson City is a clean and thorough operation. Its other attributes are difficult to define because few records are maintained. The costs of various aspects of the operation are unknown even to those most intimately associated with it. In order to determine the costs of the system, several changes in management techniques are suggested.

Daily and definite routes are recommended to replace the weekly routes now assigned each driver. Collectors who follow daily routes with an indeterminate finish, excessively inconvenience the homeowners of the community and make it more difficult for the managers to measure labor force productivity. Weekly routes assigned to only one crew give no comparative data to evaluate whether efficiencies are attributed to the crew or to the routing. It is, for instance, difficult to judge whether the crew with driver "P" finished early because of efficiency or because of covering a smaller-than-normal route section. Some routes are laid out to absorb growth in the areas they cover. On these, the crew will someday be pressed to finish, but can finish now with time to spare.

The existing system not only allows the drivers to collect daily as much of their weekly routes as they wish. It also permits choice of the sequence in which each "daily" segment is collected. No records of routing sequences or boundaries exist except in the memory of the crews. A substitute driver must rely on his memory and on directions from his helpers to complete a route.

This system of crew organization allows each driver, rather than the manager of the entire system, to determine the optimum sequence of his route.

An ideal written route description would include the following essential features:

1. An accurate description of the route by management to optimize both the individual route and the interlocking system of routes. It should include check points and the times these should be passed. The check points should be placed to encourage a reasonable but high level of productivity.

2. An accurate count of the units served, i.e., the number of homes and businesses, not the number of cans. It should include the date on which the route was last verified.

3. A space for notes concerning the operation of the system. All notes should be initialed so that further details can be obtained.

4. Space at the end for a summary which should explain the time spent on the route as an average brought up to date weekly. It should also include a record of the last truck weighing and a computation of manpower productivity. A copy of the route description without detailed notes on performance should accompany all trucks and men should be encouraged to note all irregularities in the route (see Figure 3).

JOHNSON CITY, TENNESSEE
SANITATION DEPARTMENT
Suggested Solid Waste Collection Route Description

Sheet_____ of_____

Route Number_____ Collection Day_____

Route Description Current On_____ Route Miles_____

Time Getting To Route_____ Crew_____

| ON | FROM | TO | TURN | UNITS SERVED RES. | UNITS SERVED COMM. | NOTES AND COMMENTS |
|---|---|---|---|---|---|---|
| | | | | | | |

ROUTE SUMMARY:

Total Units Served

TRUCK WEIGHED ON_____
GROSS_____
TARE_____
NET_____

Time To Complete Route_____
Average Time To Complete Route_____

Figure 3

Once the City has obtained thorough descriptions of all routes, crews and drivers may be switched among them to compare their efficiencies.

## Labor Productivity and Use

As has been suggested, Johnson City has no specific measures for labor productivity except intuitive estimates by personnel familiar with the work accomplished. This management method provides no data on which to justify what may, in fact, be sound judgment of the needs and efficiency of the system.

Productivity in solid waste management is a measure of the quantity of waste collected per unit time by members of a collecting crew. It is tempting to measure quantities according to their volume (by number of containers, number of truck loads, etc.); while this system is convenient, it yields obvious inaccuracies because density of material in trucks and in containers varies considerably. During the week of the survey, density ranged from 106 pounds per cubic yard to 633 pounds per cubic yard. The measure of productivity should be versatile enough to equate the efficiency of all modes of collection (some compacting and some not) and all crew sizes. For this reason, productivity should be expressed on a weight basis. The traditional value is in man-minutes per ton collected with adjustments for travel time to and from the regular route and for lunch and other legitimate breaks.

The average productivity during the week of the study was 186 man-minutes per ton for three-man compactor truck crews. The more productive crews showed lower man-minutes per ton figures (Figure 4).

While worker productivity is an important gage of the efficiency of the system, it does not describe whether daily routes are equitably distributed among the crews. Figure 5 charts the average weight collected by each crew on 3 days of the survey.

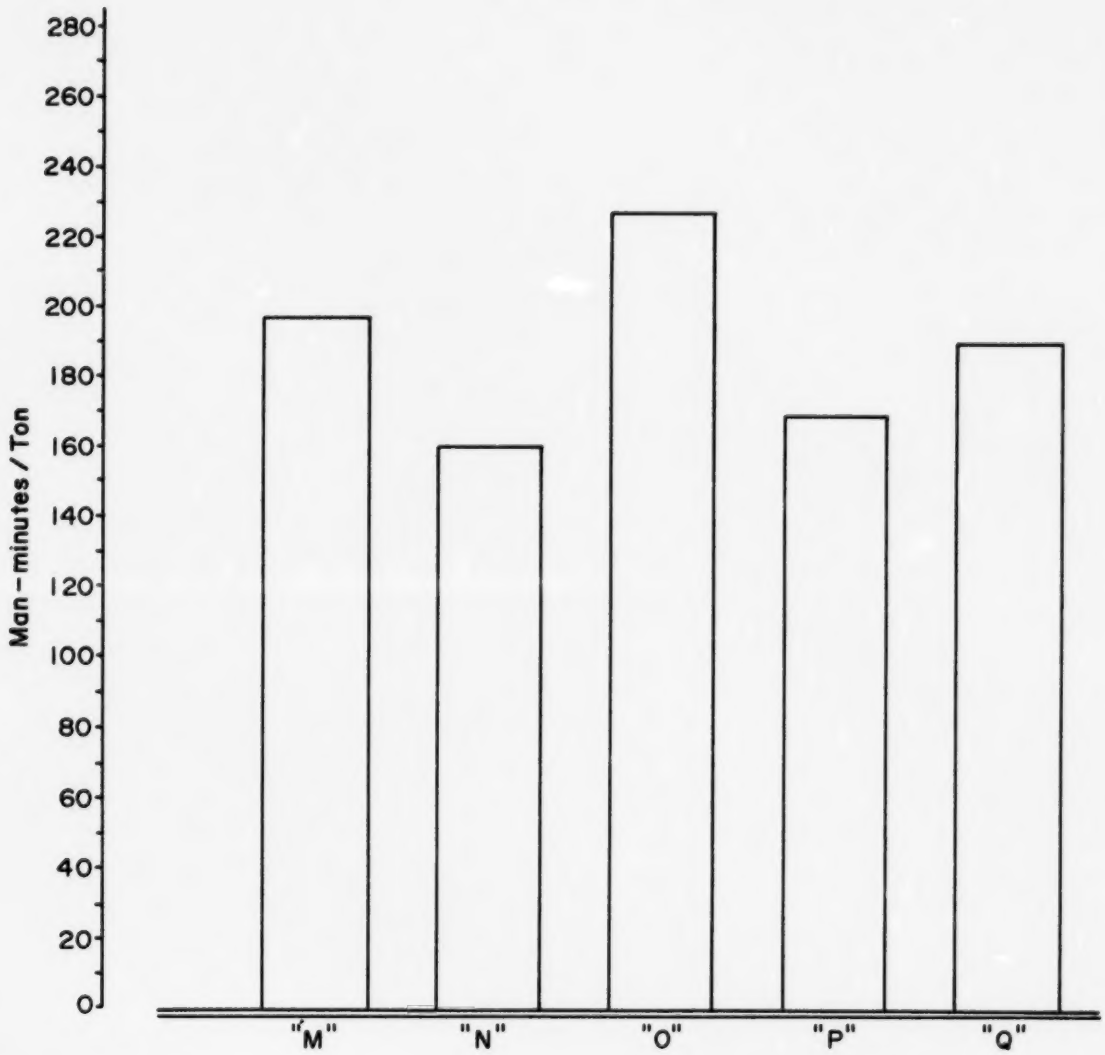


Figure 4

PRODUCTIVITY OF CREWS

Represents 3 Days of Data

(October 17, 19, and 20, 1967)

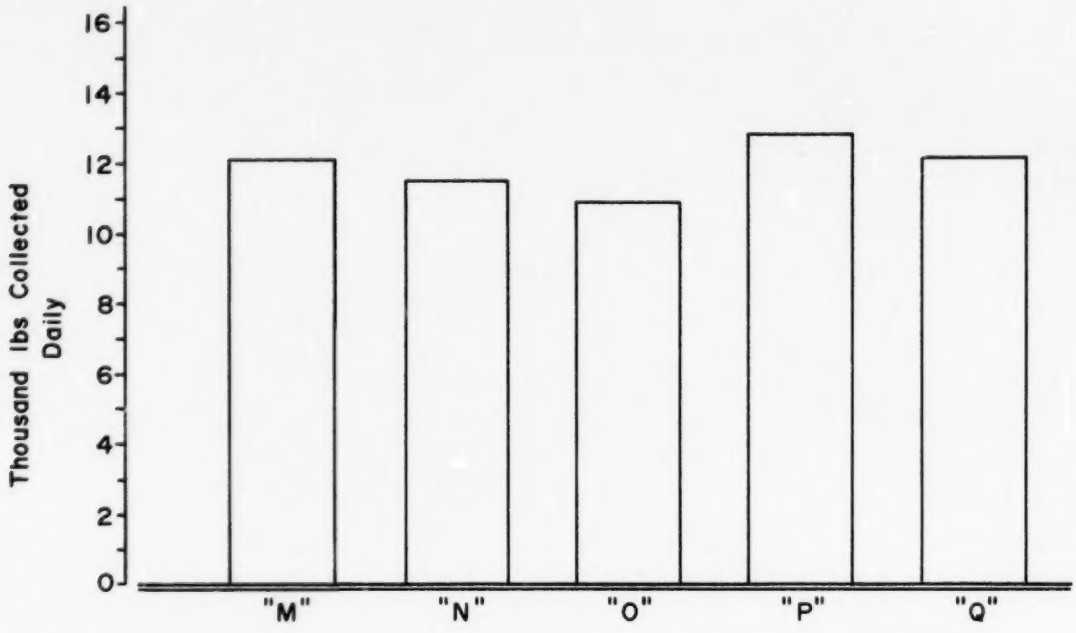


Figure 5

WORK LOAD BALANCE BETWEEN CREWS

Represents 3 Days of Data

(October 17, 19, and 20, 1967)

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Figures 4 and 5 together give an idea of which crew was most productive or which route was best laid out on the three days on which the data were noted. Whether the efficiencies come from productive crews or well sequenced routes can be discovered only by switching crews among routes or by inaugurating different, and more carefully sequenced routes. The City should conduct further measurements to detect seasonal or weekly variations in the work load and productivity between crews. An attempt to distribute the work load and balance productivity requires written route descriptions, maps, thorough planning, and the will to innovate new techniques.

A short-term study cannot result in explicit suggestions to improve routing and the use of labor. These matters require continuing analysis and innovation with supervision sympathetic to the fact that such systems are not optimized overnight and are full of numerous local constraints discovered only by trying other methods of organization, some of which will be unsuccessful.

It is important that collection records be available and that they be adequate to recognize one innovation as better than another. Such records will not be really useful without the weights of collected solid wastes. These weights can be obtained periodically at local scrap and coal yards for nominal fees.

It is recommended that records of the system's operation be reported monthly. It is also recommended that such reports should include:

1. Route changes and costs or savings resulting from attempts to improve the system.
2. Labor productivity for each route and for the entire system.
3. Costs and performance figures for each part of the operation (collection, transfer, overhead and disposal).
4. Equipment costs for each vehicle including repair costs, down time and reasons for it, and miles traveled. These figures might well be reported monthly and annually, and be related to the amounts of solid waste handled. These figures will be useful in determining the economic life of equipment and its true cost.

As the occasion arises, the Sanitation Department should submit justification based on former monthly reports, for additional bulk container service and new equipment purchases.

An annual report should state all costs incurred and describe all innovations in the system for that year.

## Commercial Waste Handling

The solid wastes from commercial establishments are collected by two modes; compactor trucks and bulk containers. There are 98 bulk containers which store and transport 60 percent of the City's commercial wastes. Wastes collected by this means cost $4.00 per ton based on the cost of 3 trucks and 2 drivers but excluding the cost of containers. (The cost climbs to $5.00 per ton with a third driver.) Smaller commercial establishments served by compactor trucks contribute 40 percent of the commercial wastes at a collection cost of $15.00 per ton based on a three-man crew. (The cost of the same crew and truck in a residential area is $9.00 per ton.)

The relatively low cost of service by bulk containers is explained by the short haul to the transfer station and by the fact that only generators of large quantities of waste own them. The high cost of compactor truck service to smaller establishments results from storage facilities which are less convenient to collectors and from the high cost of three-man crews.

Much hand labor is usually required to collect commercial wastes. The wastes, consisting primarily of paper and boxes, are usually light. Truck hoppers are quickly filled and much time is spent awaiting completion of the packing cycle. Because of the necessary wait, the City might consider using a two-man crew, with the driver assisting in loading the hopper.

Commercial collection is adequate in most respects. Daily commercial collection is provided for most establishments and for the others, far more frequently than in the residential sector. As a result, few problems exist with flies. Collection frequencies were maintained as scheduled during the week of the survey and with few exceptions, containers were collected as records stated. In a number of cases, however, the recorded container size was in error.

Productivity varied greatly between drivers. The more productive driver averaged 21 minutes per collection while the less productive driver averaged 25 minutes per collection.

No criteria exist for the use of bulk containers, their purchase being primarily the option of the particular waste generator. This results in special time consuming compactor crew service to a few establishments who have not been motivated to purchase them. City time-motion records gathered in June, 1966 and personal interviews conducted by study team members during the week of the study revealed that as much as an hour is spent at one supermarket where cartons are retrieved from the basement. Another commercial stop requires collectors periodically to shovel ash residue from a masonry bin.

Commerce in Johnson City produces 38 percent of the city-collected solid wastes at a cost of about 40 percent of the total.

## Industrial Waste Handling

Industrial solid wastes are an insignificant fraction of the city-collected wastes. The fact that seven industries are served, however, points to weakly defined policies and ordinances governing the City's collection of industrial wastes. The City should define its role in the regulation and collection of industrial solid wastes and apply a uniform policy throughout the City.

## COST ALLOCATION AND FINANCING THROUGH SERVICE CHARGES

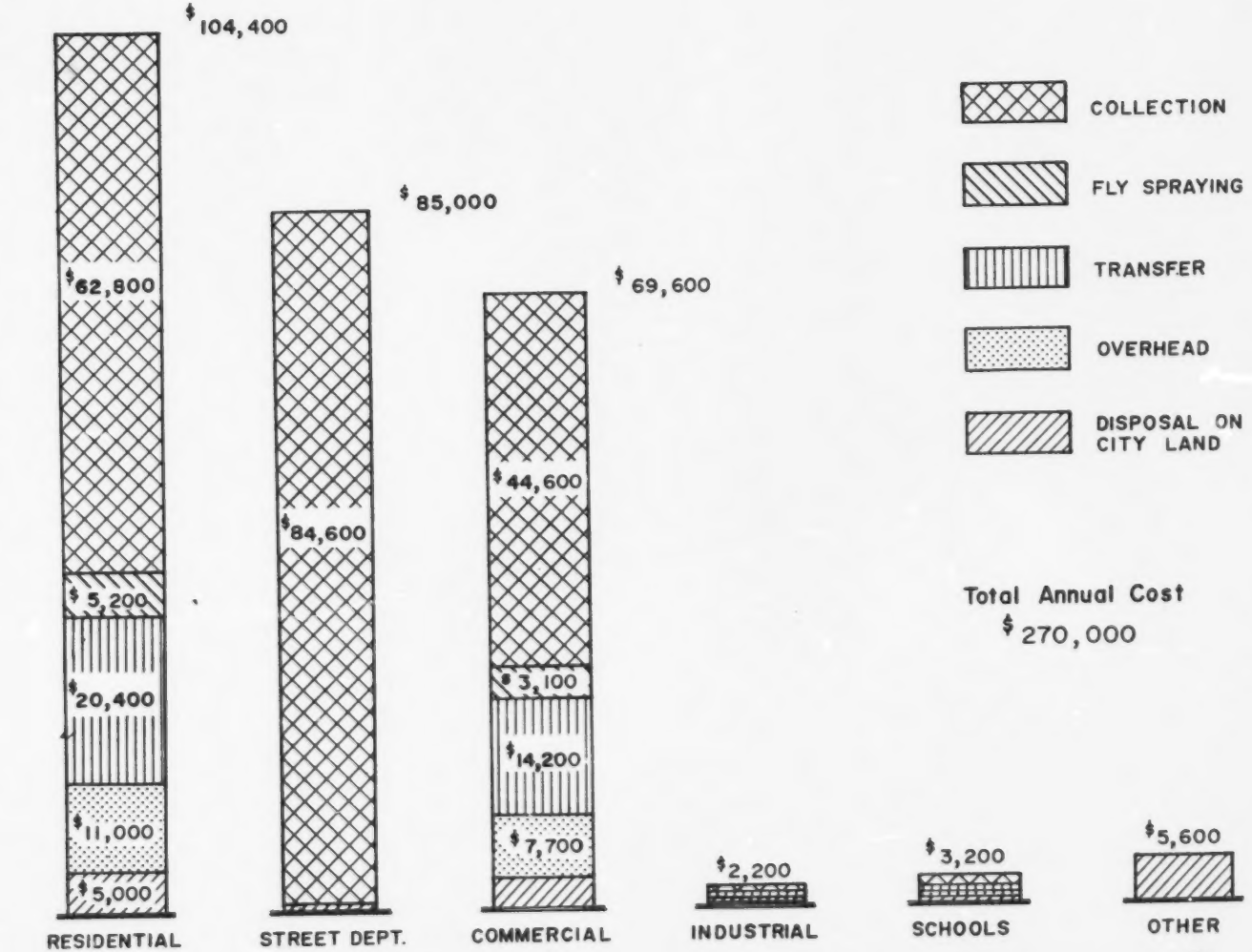
The costs of solid waste collection from the residential, commercial, and industrial sectors should be equitably allocated among those sectors. Many communities feel that the cost of service to the commercial sector, for instance, should be proportional to the waste it generates and equal to the tax money it contributes toward the service. Should the costs of solid waste collection of any sector be greater than justified by taxes to that sector, the true costs of the services contributed by that sector are not reflected in the price of the service. In effect solid waste collection from that sector receives a subsidy from the other sectors. Wastes from schools and libraries and from other municipal activities such as street and storm drain cleaning receive this subsidy. Whether or not such diseconomies are practiced by the City is a matter of policy.

Two basic philosophies dominate financing solid wastes handling systems. When solid waste collection is regarded as a utility, charges are proportional to the amount of service provided. However, when collection is conducted as a necessary measure to maintain community health, it is financed as are roads and schools through a general tax revenue.

Costs and allocations of solid waste collection are charted in Figure 6. Detailed tax data were not available to determine whether or not costs and charges were properly allocated, however, such information is easily applied when obtained.

Cities which finance solid waste handling with a service charge attempt to allocate the costs of the service strictly as a utility. As a utility, the charge to each user is proportional to the service rendered. The primary advantage of this system is that it frees general tax revenues for other purposes. It also requires that cost records be kept and used to justify innovations and charges in the system.

The service charge, however, is not a universal panacea for the problems of solid waste management. Before such a charge can be inaugurated, numerous details must be considered.




ANNUAL COST OF SOLID WASTE HANDLING BY ITEM AND SECTOR

Figure 6

A workable service charge requires a simple means of fixing charges, billing householders, and dealing with delinquent accounts. Such a system must also meet or completely exclude competition from private collectors. This move in Johnson City would require additional regulatory codes if the City is to maintain control over the quality of service.

Several methods of fixing charges are used in the many cities using the service charge system of financing. The three which seem most applicable to residential collection in Johnson City are:

1. Flat rate for all residences
2. Rate proportional to the time spent collecting at each residence
3. Rate proportional to the volume or weight produced at each residence.

A flat rate charged all residences is the most economically administered system. It works on the assumption that services do not differ appreciably between residences and that all receive equal service. This, of course, is not always true.

Billing at a rate proportional to the time spent on individual collections is certainly the most equitable means of distributing costs. However, this system requires extensive records and manpower to obtain basic time data which must be collected and averaged regularly.

Solid waste collection charges based on the volume (number of containers) or weight collected from each household are easily determined and seldom change significantly. Such a system encourages overloaded cans and the use of unauthorized containers or boxes. The system also encourages backyard burning to reduce volume, a practice which should be discouraged because of its contribution to air pollution. Extensive records are required when this system is used.

Financing solid waste collection with a service charge makes the service sound optional. Some citizens may seek to avoid any collection or may haul wastes themselves in order to avoid the charges. Experience has shown that people electing this option often do not provide themselves with adequate service. For this reason it is wise to legislate so that all citizens receive regular collection service by approved collectors. If private collectors are allowed to provide this regular service in competition with city forces, they should be licensed to insure compliance with city standards.

Billing commercial and industrial establishments is more difficult than billing households. One finds great variance in the quantities of wastes from commerce and industry as well as variation in

collection frequency. Johnson City also employs two distinct modes of collection which must be considered. For these reasons a flat rate charged to commerce and industry is unworkable. Instead, a fee based on time required or quantity collected is more appropriate.

Special fees for solid waste collection are usually billed on existing accounts because of the great expense of separate billing. Most cities include charges or fees with water or tax bills regularly sent to citizens. Special billing to commerce and industry is hard to avoid because special bills should go to building tenants, and not the land owners who pay taxes on the property. Unless tenants are forewarned, the sudden appearance of a special bill for solid waste collection will cause great confusion.

# EQUIPMENT USE

Solid wastes are collected by many types of trucks in Johnson City. The Street Department uses standard street sweepers, suction leaf collectors and open trucks for brush collection and catch basin cleaning. The Sanitation Department uses enclosed compactor trucks, bulk container hoist trucks and semi-trailer transfer vans.

No detailed information was gathered to evaluate the use of Street Department equipment. It was felt that the equipment was standard and that its effective use depended principally on the skill of the labor operating it.

The Sanitation Department received closer scrutiny because its equipment is closely associated with the efficiency and economy of their highly routine system.

## Compactor Vehicles

Collection trucks with compactor mechanisms were not operated at true capacity during the week of the study. Since wastes are pressed into truck bodies of constant volume, they are not considered full until they are "packed out", until the packing blade meets a resistance too great to overcome. Whether a truck is actually full when "packed out" can only be determined by obtaining weights and calculating the density of material in the truck. A truck can be "packed out" long before it contains waste at maximum densities. This happens when hoppers are loaded too full between packing operations and the material bridges creating voids in the load. The average density of wastes in compactor trucks was 357 pounds per cubic yard with a maximum value of 633 pounds per cubic yard. The latter is about what can be expected with optimum operation.

It should be pointed out that maximum densities are not required of most collectors under the present work loads and productivity. Extra capacity is available when it is needed, however, and can be attained by more careful operation.

The Sanitation Department operates 5 compactor trucks daily, holds a sixth truck in reserve and has a seventh truck for a night route. This practice actually leaves 2 trucks idle during the day. The reasons behind this practice are not clear. It is assumed that one reserve truck is adequate to assure uninterrupted service and that reserving a truck strictly for night service is unnecessary. A night crew could use any of the 4 trucks used for daily residential routes (Figure 7).

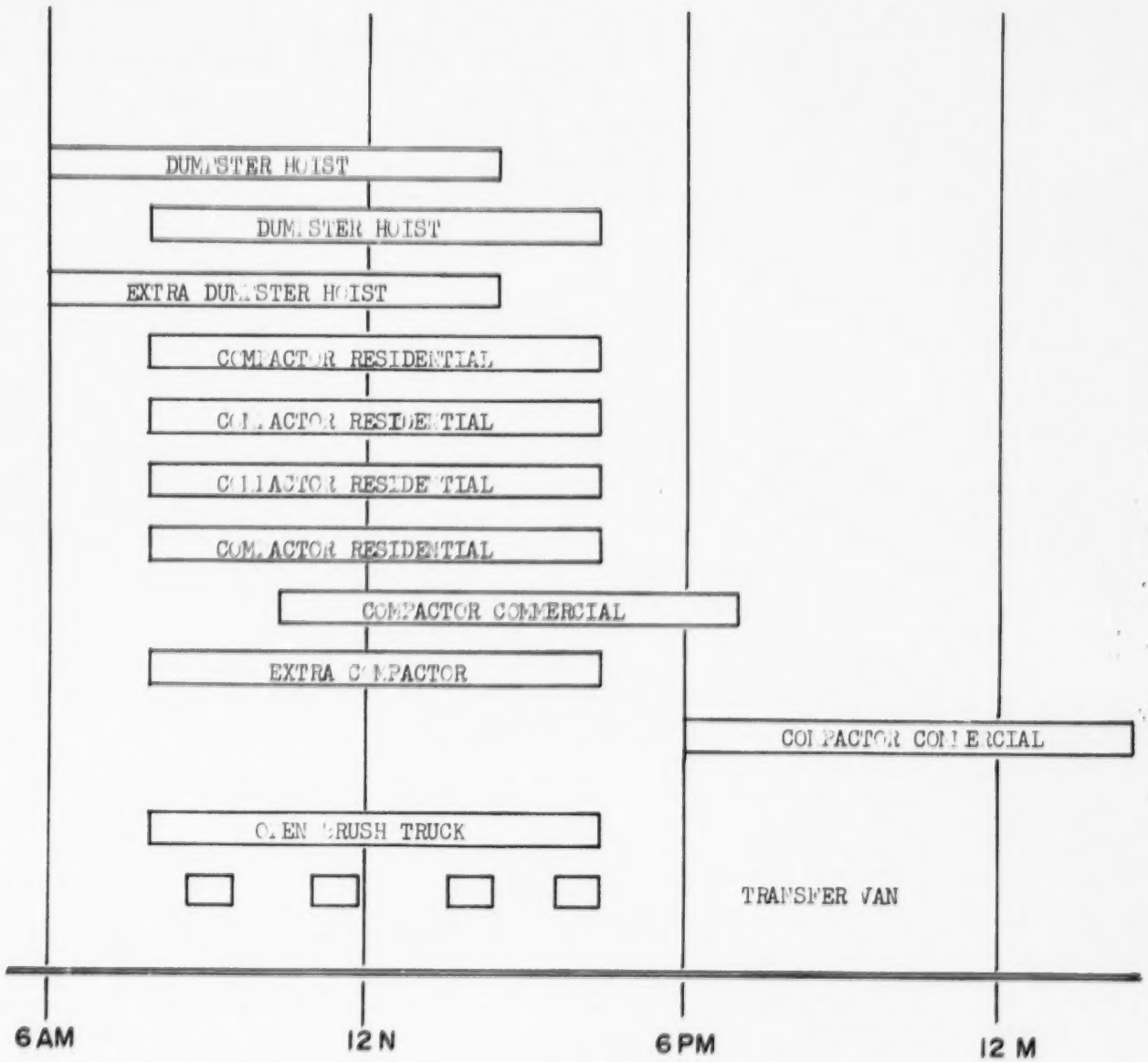



Figure 7

TIMING OF SANITATION DEPARTMENT EQUIPMENT USE

## Bulk Containers

The bulk container system used by the City is the Dempster Dumpster* line. Large privately owned containers throughout the City are serviced by trucks which carry them to the transfer station, empty and return them to the owner. Large containers allow mechanized handling of large quantities of solid waste generated at single points. It provides clean and uncluttered storage for areas which would require as many as 20 to 30 small cans.

The Dempster Dumpster system used differs from most other bulk container systems by requiring a full round trip to the disposal site for each container. With regularly scheduled service every container is not filled to capacity. Most containers are serviced frequently enough that owners are not inconvenienced by a receptacle which is too full to use. However, containers filled with food wastes must be serviced not necessarily when full, but when their contents start to smell excessively and are attractive to rodents and flies. During the week of the study containers carried on the average, only 54 percent by volume of their design capacity (See Figure 8.) Annual costs of the current Dumpster system are detailed in Appendix B-II.

Other bulk container systems employ trucks which mechanically empty containers without transporting them. These trucks also compact the waste to between one-third and one-quarter of their original volume. Johnson City's current Dumpster system hauls uncompacted wastes. It is estimated (Appendix A) that 1 unit which empties containers on site (one brand name is the Dempster Dumpmaster*) could replace 3 Dumpster hoist trucks at a considerable savings. Unfortunately, manufacturers have not made interchangeable containers for the two systems. Johnson City, in going to the more economical system, would probably have to modify existing containers or aid present owners in purchasing different ones.

## Solid Waste Transfer

Transfer of solid wastes in large vans is economically justified when the cost of transfer is less than the cost of all collection trucks traveling to a disposal site. Calculations show that the cost of transfer operations exceed the cost of direct haul by $13,000 each year (Appendix A**.) Calculations further show that if transfer operations were stopped and the Dumpmaster type system of bulk containers were used, and excess equipment sold, the City would save $37,000 annually over the systems now in use.

*The use of names of commercial products does not imply endorsement by the U. S. Public Health Service.

**Appendix A shows a savings of $27,000 from this change. This savings is for operations with only 6 of the present 7 trucks.

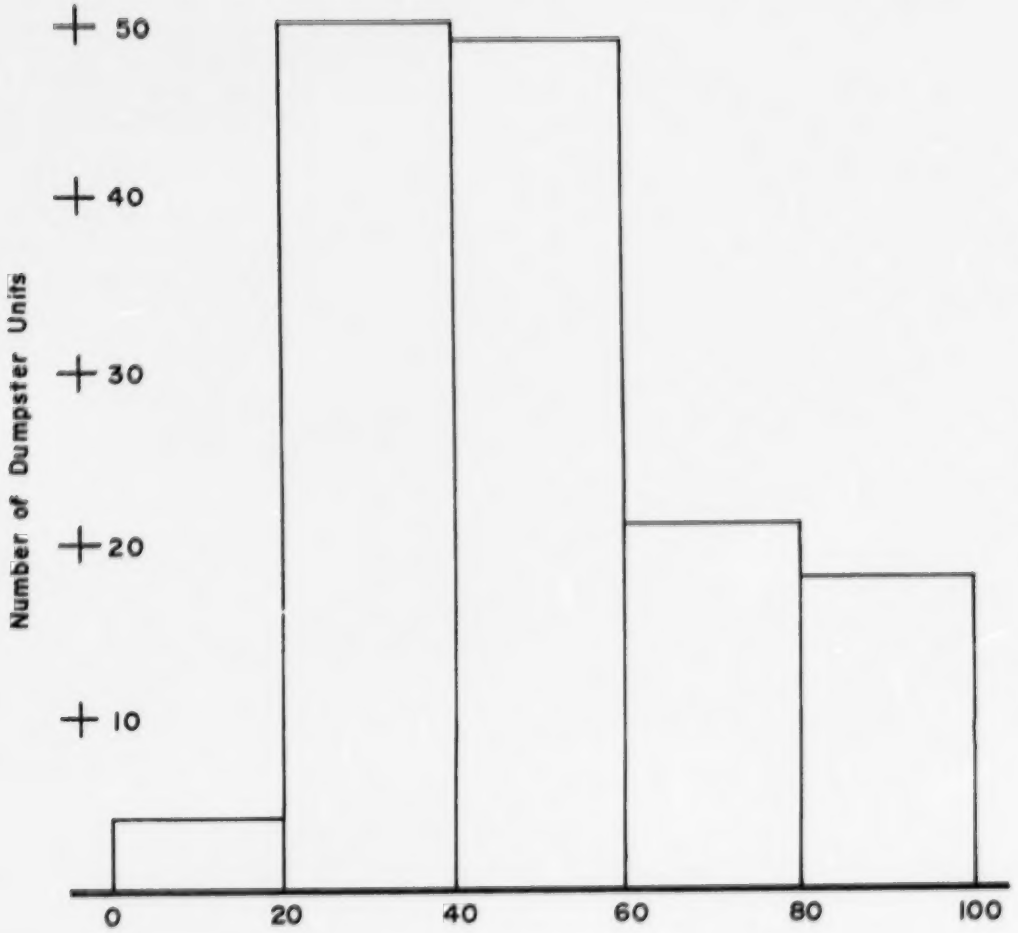



Figure 8

USE OF BULK CONTAINERS

Represents 4 Days of Data

(October 16, 17, 19, and 20, 1967)

The transfer operation falls short of its goal of cost reduction because the haul distances to the disposal sites (dump or compost plant) are so short. The round trips can be made easily in 30 minutes. Street Department trucks make the trip daily to the city dump since they do not use the transfer system.

Operation of the transfer system is well conducted, although drain cocks on the trailers were never closed and vans trailed a spray of polluted water on each trip. Drain cocks should be open only when the vehicle is being cleaned.

A full discussion of the alternatives to solid waste transfer is found in Appendix A.

# SOLID WASTE DISPOSAL

## City Dump

As previously described, operation of the city dump falls well below approved levels and is not operated as well as the private dump near Jonesboro, which is in a more isolated location. To be operated properly, open burning must be stopped, daily cover provided, and operations planned to make full use of the land. The City should keep in mind the use to which the land will be put once filling operations are completed and the land reclaimed.

The old Chilhowie site exemplifies use of reclaimed land. A portion of this site is now Civitan Park, while the rest of the site is not finished and is still used for dumping leaves and catch basin wastes.

## Composting

The only wastes regularly collected in or around Johnson City that are particularly detrimental to the composting process are hospital and medical center wastes. These hospital wastes consist of used hypodermic needles and dressings. Although it has not been proven, it is likely that these wastes threaten the health of the composting plant workers who must remove them, by hand, from the process. It is estimated that 12,000 pounds of such wastes are collected weekly by the City, some of which may reach the compost plant.

A few sources of wastes particularly beneficial to composting were noted. Large supermarkets and restaurants generate substantial quantities of produce and other food wastes which are high in nitrogen. Such wastes are prized as hog feed by area farmers and this constant demand for them would seem to preclude their collection by city forces and their being processed at the composting plant.

Johnson City has a very active salvage market and most large quantities of commercial solid wastes are collected and sold, or used privately. Many supermarkets segregate cardboard boxes and store them in large bins for private collectors. Meat scraps from restaurants and butcher shops are collected for rendering. High-grade broken soft drink bottles are collected from local bottling plants and reclaimed in Knoxville, Tennessee.

The best source of organic wastes seems to be the residential sectors in and around the city. Almost 26 percent by weight of the residential solid wastes are food wastes and will compost well. The only major source of additional residential wastes around Johnson City are those collected by the Washington County Utility District. Trucks serving the peripheral areas of Johnson City are within haul distance of the compost plant and contain solid wastes from almost purely residential sources. The owners of the Washington County Utility District have expressed a sincere interest in cooperating with the plant in the delivery of these wastes.

City transfer vans now deliver solid wastes to the compost plant before the processing crews arrive. This early arrival is achieved by holding a full transfer van overnight and driving it out early in the morning. This seems satisfactory and is probably the best procedure possible under the current system of transfer.

Should the city cease transferring wastes and haul directly to the compost plant or city dump, other arrangements will be required. It has been suggested that routing also be revised to use manpower more efficiently and decrease the average haul to the disposal site. It is believed that direct haul by individual trucks can provide working schedules similar to those followed now.

## DISCUSSION OF ORDINANCES COVERING SOLID WASTES HANDLING IN JOHNSON CITY

The collection of solid wastes is covered in Chapter 14 of the Johnson City Code (1951). These codes cover many contingencies in great detail but fail to describe the solid wastes handling system as it exists in the City.

The code fails to assign responsibility for solid wastes collection and does not describe the service the citizens should expect from collectors.

Responsibility for collection of all residential and commercial solid wastes should be entrusted to a single official. This person should be bound by ordinance to provide adequate and equitable service to the citizens. Requirements should include that detailed records of costs and procedures be regularly forwarded to supervisory officials.

Article II entitled "Garbage" actually deals with solid wastes collection from residential and commercial sources but is extremely vague about collection from industry. The ordinance holds owners and tenants of these establishments responsible for storage of the wastes they generate. It does not describe the important detail of how food wastes are to be prepared for storage. Food wastes should be thoroughly wrapped in newspaper to prevent flies from laying eggs on the organic material.

The ordinance permits the use of metal cans only, yet fails to describe the minimum capacity required at each site. Recent technology has made plastic cans as satisfactory as metal ones and their use should not be discouraged. The City should provide more definite guides to the quantity of storage required. It is reasonable to require on-site storage sufficient for a week and a half where there is weekly collection, to allow for unforeseen delays in service.

The ordinance states that storage containers will be "placed in a convenient, accessible location for trucking." It does not state that this placement is required only on collection days designated by a responsible authority. As a result, many cans are always stored in these places convenient to trucking but all too visible to the public.

The rationale for special services to 9 percent of the citizens of Johnson City is the result of varying interpretations of which places are convenient to trucking. In many instances cans are "made accessible" by backing trucks into driveways. Ordinances should specify collection points.

Only burning on bituminous pavement is prohibited in the ordinance. It is recommended that all open burning, except that done for recreational purposes, be outlawed both within the City and at the city dump. Such a prohibition would be Johnson City's first step toward air pollution control that is considered desirable in most American cities.

The third article of the ordinance entitled "Sanitary Garbage Fill" deals with disposal of solid wastes. This article contains no definitions for the various terms used, such as "Garbage Fill" and "Refuse Fill". As mentioned previously in this report, the city disposal site is not a sanitary landfill because there is no daily compaction and cover and open burning is practiced. It is strongly recommended that ordinances specify higher standards for operating this site.

It is felt that the exclusion of sawdust and mica dust at the dump is an unwarranted measure which only provokes disposal by other less controlled means. City officials should seriously consider special provisions for infectious hospital, clinic, and animal clinic wastes. The Tennessee Department of Public "Minimum Standards and Regulations for Hospitals", Section 305.5, states that "all infected dressings, surgical and obstetrical wastes shall be incinerated".[5] Only the Veterans Administration Hospital incinerates such waste regularly. In the other hospitals and clinics great leeway is taken in interpreting what is indeed infectious. It is felt that sizeable quantities of wastes dangerous to personal health are regularly handled by city forces.

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1. Rogers, P. A., and G. J. Bellenger. Fly and economic evaluation of urban refuse systems. II. An efficiency analysis of paper bag containers. California Vector Views, 14(5):29-36, May 1967.

2. Scott, H. G., and K. S. Littig. Flies of public health importance and their control. V. A training guide in the insect control series. Atlanta, National Communicable Disease Center, 1962.

3. An analysis of refuse collection and sanitary landfill disposal. Technical Bulletin No. 8. Sanitary Engineering Research Project. Richmond, University of California, Dec. 1952. Series 37. p. 46.

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The State of Tennessee Department of Health provided assistance to the study by assigning Mr. Ronald Gasser to aid Technical Services in conducting the study.

Members of the study team from the Solid Wastes Program were:

| | |
|---|---|
| Morris G. Tucker | Charles S. Spooner, III |
| Charles W. Reid | Billy P. Helms |
| John J. Giar | Tobias A. Hegdahl |
| Walter W. Liberick | Joseph E. Shandling |

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This report was prepared by Charles S. Spooner, III, Staff Engineer, Consultation and Investigations, Technical Services, Solid Wastes Program.

# APPENDICES

# APPENDIX A

# ECONOMIC AND ENGINEERING ANALYSIS OF THE ALTERNATIVES TO THE EXISTING SYSTEM OF SOLID WASTE HANDLING

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## APPENDIX A-I

## ALTERNATE EQUIPMENT

The purpose of this appendix is to evaluate the alternatives to the current system of solid waste collection and transfer. Three alternatives discussed are:

1. Continue to use the present system
2. Change portions of the system immediately
3. Change portions of the system in the future.

The costs of continuing to use the present system are detailed in Appendix B. The costs there are not based on the original cost of the equipment, but on its present estimated resale, "realizable", value. A summary of those costs appears below.

Estimated 1967 Annual Cost of the Present System

| | |
|---|---|
| Overhead | $ 19,221 |
| Compactor Collection | 91,189 |
| Bulk Container Collection | 16,492 |
| Transfer | 28,010 |
| Disposal | 14,673 |
| Total | $169,585 |

In changing the system immediately, there are two choices: (1) Eliminate transfer operations and sell the transfer vans for their realizable value; (2) Sell the transfer vans and the bulk container hoists trucks and purchase an alternate Dumpmaster type truck to handle bulk containers.

If transfer were eliminated, collection trucks would have to haul directly to the disposal site with an obvious increase in operating costs of those trucks. The compactor trucks which make two trips to the transfer stations, would make 2 trips to a disposal site each day. Assuming a round trip of 30 minutes, the increase in time would be an hour each day. During the study week crews spent an average of 6 hours and 20 minutes collecting and received 8 hours pay. If this much time is spent collecting throughout the year, the additional hour for the trip to the disposal site should be possible without overtime pay. If needed, the last trip could be made with the driver only to provide incentive for the crew to finish early.

Annual Cost of an Average Compactor Truck

| | | |
|---|---|---|
| Depreciation | $ 800 | Unchanged |
| Maintenance & repair | 1,547 | $400 increase |
| Insurance | 88 | Unchanged |
| Tires | 366 | $100 increase |
| Fuel & lubrication | 610 | $200 increase |
| Crew | 10,296 | Unchanged |
| Total | $13,707 | vs. a former cost of $13,027 |

The annual cost for 6 trucks would be about $87,500 assuming the extra truck is sold as suggested in the section on equipment use.

As one might expect, the cost of operating the bulk container hoists is greatly increased without transfer. This results from the relatively short economic haul distance when trucks must load, haul, empty, and return each container.

Without transfer, the third dumpster hoist would be used. Currently drivers average 23.3 minutes per collection and work an average of 7 hours per day. The extra distance to the disposal site would require an extra 30 minutes, or 53.3 minutes per service. This would require 24 man-days per week for service, or 3 daytime crews and a night crew six days per week.

Annual Cost of an Average Dumpster Hoist Truck

| | | |
|---|---|---|
| Depreciation of hoist | $ 214 | Unchanged |
| Depreciation of chassis | 345 | Unchanged |
| Maintenance and repair | 1,000 | $200 increase |
| Insurance | 88 | Unchanged |
| Tires | 160 | Tire costs double |
| Fuel and lubrication | 1,000 | Costs doubles |
| Crew at $1.80 per hour | 5,986 | Reflects the cost of four drivers |
| Total | $8,793 | vs. a former cost of $5,497 |

The annual cost of three trucks: $26,379

Based on the cost estimates mentioned previously, eliminating the transfer station will result in the following annual costs to the City:

Annual Cost Without Transfer

| | | |
|---|---|---|
| Overhead | $ 19,221 | Unchanged |
| Compactor collection | 82,250 | See above |
| Bulk container collection | 26,379 | See above |
| Disposal | 14,673 | Unchanged |
| Total | $142,523 | |

The annual savings over the present system: $ 27,062

Although eliminating the transfer station allows some savings, the cost of bulk container service nearly doubles in the system without transfer. It is desirable to look toward alternate

methods of handling bulk containers. Two alternate schemes seem to be: (1) Replace hoist trucks with a more economical truck which does not haul uncompacted wastes and containers to the disposal site; (2) Retain the present bulk container trucks and use only one transfer van exclusively for them.

The type of truck described above to replace the hoist trucks is manufactured by several companies. The compacting mechanism in them can reduce the 180 cubic yards of waste collected daily in bulk containers to 60 cubic yards. If the new truck had 30 cubic yard capacity, this would result in 2 trips to the disposal site and service to 35 bulk containers each of six days a week. The annual cost of such a system would be:

| | |
|---|---|
| Capital cost | $26,000 |
| Useful life-years | 7 |
| Salvage | 2,500 |
| Annual depreciation | 3,357 |
| Maintenance and repair | 3,000 |
| Insurance | 140 |
| Tires | 400 |
| Fuel and lubrication | 300 |
| Crew (2 men) | 8,611 |
| Total | $15,808 |

This would be an apparent savings of nearly ~~$31,683~~ 37,633 annually from the present system -- but there are complications. The manufacturer has not made the containers to fit both types of trucks, thus the existing containers will have to be replaced or modified. The effort, however, might be justified since the number of bulk containers is certain to increase as are the savings between the systems.

It is helpful to look into the economics of operating one transfer van on a limited scale for the sole use of the existing bulk container system. Such a system may prove to be the only one feasible because of the costs of replacing or modifying the existing containers. It might also prove a satisfactory scheme while converting existing bulk containers to fit a new truck.

If a single transfer van is used, it must be decided which one Johnson City should keep. The selection must be based on both cost and capacity. Appendix B-III shows the current annual cost of transfer. It shows that the older vehicle costs more each year than the newer one - that it has reached its economic life and should be sold. Required capacity has already been discussed and is 180 uncompacted cubic yards a day. This can be handled by the newer transfer truck in two loads.

With such infrequent use, it seems reasonable to hire only a driver who could clean the transfer station between his runs. The resulting transfer costs would be:

| | |
|---|---|
| Vehicle depreciation | $ 3,170 |
| Operations and maintenance | 6,000 |
| Transfer station amortization | 700 |
| Vehicle operator at $1.85/hr. | 3,848 |
| Total | $13,718 |

| | |
|---|---|
| Overhead | $ 19,221 |
| Compactor collection | 82,250 |
| Bulk container collection | 16,490 |
| Transfer | 13,718 |
| Disposal | 14,673 |
| Total | $146,352 |

This would be an annual savings of $23,233 from the present system but still $14,400 more than a new bulk container system without transfer would be.

## Conclusions

There are a variety of systems more economical than the present one. Operating a transfer station for all solid wastes in Johnson City is unjustified, as was its original purchase. The original cost of the system cannot be recouped, however, and the best system must be rebuilt with the existing investment.

It is recommended that one compactor truck and the older transfer van be sold immediately, and that compactor trucks haul directly to the disposal site. Bulk container hoist trucks should use the remaining transfer van, while a new truck for bulk container handling is purchased and bulk containers are modified or replaced.

# APPENDIX A-II

## BAGGED STORAGE

City officials have shown particular interest in the "bagged system" of solid waste storage. The system replaces metal cans with special paper bags which are thrown away along with the wastes they contain. Articles in public works magazines have claimed spectacular cost savings from their use although records of their true cost are still shrouded in the mist of exaggerated claims. Most reports of savings from the system result from concurrent operational changes (such as going from carry-out to curbside service) or other efficiencies suggested by representatives of the bag manufacturers.

The bag-system generally costs the homeowner more money than he would otherwise pay, but because collection efficiency is increased, collection costs are lower. Unless the savings to the City are passed on to the citizen through lower fees or taxes or through subsidized bag purchases, the system will be less favored by the citizen.

Few credible studies on which to base true cost estimates exist. Estimates based on one study* show a probable savings in collection costs of 15 percent. This would amount to an annual savings to Johnson City of $10,000 but this would be counterbalanced by a cost of more than $50,000 annually for bags. These figures do not include the cost of bag holders, which are about $6 each nor the loss of an estimated $60,000 invested in cans throughout the City.

*Rogers, P. A., and G. J. Bellenger. Fly and economic evaluation of urban refuse systems II. An efficiency analysis of paper bag containers. California Vector Views, 14(5):29-36, May 1967.

## APPENDIX A-III

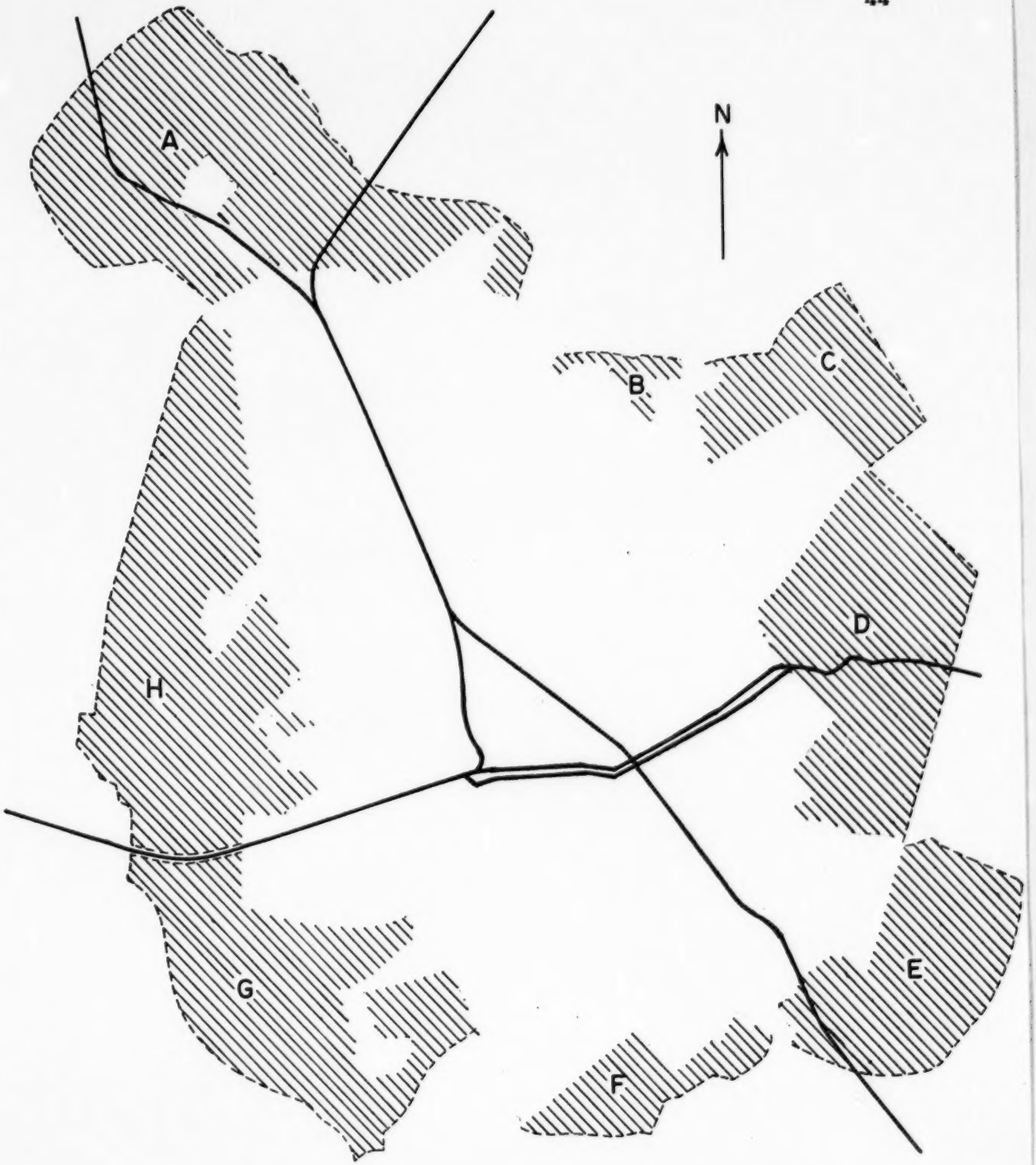
## PLANNING FOR FUTURE ANNEXATION

In planning for future annexation, Johnson City will be faced with two waste-related problems. The City Sanitation Department will have to provide collection service to the citizens of these areas, and city ordinances will have to cover solid waste storage in these areas.

The eight areas of possible annexation are noted on the map in Figure 9 where they are denoted by letters. Detailed information on the necessary men and equipment to service each section are noted in Table 1-A. The figures are based on the generation of 30 pounds per household per week. There are too few commercial establishments in any of these areas to warrant separate commercial routes but small groceries and restaurants will require service more frequently than once a week.

Complete annexation of all the areas noted will replace private collection service with municipal service. If all sections are annexed, the private collector would lose about one-third of his customers.

Ordinances covering solid waste handling, if ammended as suggested in this report will be sufficient to regulate the annexed areas with the exception of junked automobiles. Junked automobiles, both in organized junk and salvage yards and on private land, are serious problems in sections D and G. Most cities and some states require that collections of more than 4 or 5 inoperable automobiles be shielded from public view. Other cities limit the time junked or abandoned automobiles may remain on private property. The City should be prepared to meet this problem when annexing these areas.




AREAS OF POSSIBLE ANNEXATION
Johnson City, Tenn.

Figure 9

SOLID WASTES IN AREAS CONSIDERED FOR ANNEXATION

| Sector | Number of homes | Private Collection | | Collection day | Active collection hours required | Anticipated | | Collection costs/yr[c] |
|---|---|---|---|---|---|---|---|---|
| | | Number of homes now served | Percent of homes now served | | | lb/wk[a] | MH/wk[b] | |
| A | 387 | 185 | 47.8 | Thurs, Fri | 7.5 | 11,610 | 18 | 4,945 |
| B | 11 | 0 | 0 | - | - | 330 | 0.5 | 142 |
| C[d] | 325 | 93 | 28.6 | Monday | 6.5 | 9,750 | 15 | 4,193 |
| D[e] | 375 | 8 | 2.1 | Monday | 7.5 | 11,300 | 16 | 4,859 |
| E | 450 | 390 | 20.0 | - | 9.0 | 13,500 | 21 | 5,800 |
| F | 4 | 0 | 0 | - | | | | |
| G[f] | 942 | 426 | 45.2 | Mon, Tues | 19.0 | 28,200 | 44 | 12,126 |
| H | 469 | 101 | 21.5 | Tues, Wed, Fri | 9.3 | 14,100 | 22 | 6,192 |

[a] Based on 30 lb/household/wk.

[b] Based on 186 man min/ton.

[c] Based on current cost of $15.50/ton for collection only.

[d] Section C contains demolition salvage operation.

[e] Section D contains 3 automobile junk yards, promiscuous dumps, and yards littered with junked cars.

[f] Section G contains 1 automobile junk yard.

TABLE 1-A

# APPENDIX B

## ITEMIZED COST OF THE CURRENT SYSTEM

## OF

## SOLID WASTE HANDLING

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The costs cited in this appendix are approximate but were estimated or extrapolated from known data. They are presented here to substantiate conclusions drawn from them and are itemized to allow updating when necessary.

Most of the items footnoted as "estimated" are resale values or remaining life of the equipment currently owned. These figures were estimated with the aid of Johnson City officials, equipment dealers and advertized prices of used equipment.

The items whose costs were based on 10 months of records were taken from the official records of Johnson City. These costs were extrapolated over an entire year.

The cost of collection labor were those given the study team by the Head of the Department of Sanitation.

APPENDIX B-I

ANNUAL COSTS OF COMPACTOR TRUCKS

| Truck Number | 825 | 872 | 879 | 889 | 890 | 891 | 898 |
|---|---|---|---|---|---|---|---|
| Remaining life-years[a] | 2 | 5 | 5 | 1 | 1 | 2 | 4 |
| Net realizable value[a] | $ 3,800.00 | $ 9,800.00 | $ 9,800.00 | $ 3,200.00 | $ 3,200.00 | $ 3,800.00 | $ 6,600.00 |
| Salvage[a] | 2,800.00 | 2,800.00 | 2,800.00 | 2,800.00 | 2,800.00 | 2,800.00 | 2,800.00 |
| Depreciation/year | 500.00 | 1,400.00 | 1,400.00 | 400.00 | 400.00 | 500.00 | 950.00 |
| Maintenance and Repair[b] | 2,012.93 | 525.36 | 500.80 | 1,336.67 | 1,249.31 | 1,323.83 | 1,083.10 |
| Insurance[b] | 88.40 | 88.40 | 88.40 | 88.40 | 88.40 | 88.40 | 88.40 |
| Tires[b] | 266.47 | 452.64 | 220.00[a] | 171.80 | 278.35 | 347.33 | 90.76 |
| Fuel and lubrication[b] | 310.26 | 688.46 | 600.98 | 345.35 | 328.75 | 295.36 | 420.26 |
| Crew[c] | 10,296.00 | 10,296.00 | 10,296.00 | 10,296.00 | 10,296.00 | 10,296.00 | 10,296.00 |
| Total annual cost | $13,474.06 | $13,450.86 | $13,106.18 | $12,638.22 | $12,740.81 | $12,850.92 | $12,928.52 |

Total Annual Cost for All Compactors $91,189.57

[a]Figures estimated.

[b]Based on 10 months of records.

[c]Based on 260, 8-hour days/yr at $1.60/hr for each of two helpers and at $1.75/hr for drivers.

## APPENDIX B-II

## ANNUAL COST OF BULK CONTAINER HOISTS

| Truck Number | 841 | 892 | 809 |
|---|---|---|---|
| Net realizable value of hoist[a] | $4,000 | $4,000 | $ 500 |
| Remaining life (years)[a] | (1) | (12) | (1) |
| Salvage[a] | 500 | 500 | 500 |
| Annual depreciation of hoist | 350 | 292 | 0 |
| Net realizable value of chassis[a] | 1,800 | 2,800 | 1,800 |
| Remaining life (years)[a] | (1) | (3) | (1) |
| Salvage value[a] | 1,500 | 1,500 | 1,500 |
| Annual depreciation of chassis | 300 | 434 | 300 |
| Maintenance and repairs[b] | 697 | 1,502 | 1,597 |
| Insurance[b] | 114 | 88 | 88 |
| Tires[b] | 79 | 80 | 165 |
| Fuel and lubrication[b] | 565 | 528 | 393 |
| Driver (6 day week)[c] | 4,460 | 4,460 | --[d] |
| Total Annual Cost | $6,565 | $7,384 | $2,543 |

Total Annual Cost for Dumpster Hoist Service $16,492

---

[a]Estimated from best available sources.

[b]Based on 10 months of records.

[c]Based on $1.80 per hour.

[d]Truck currently without a driver, used as an extra truck.

APPENDIX B-III

ANNUAL TRANSFER COSTS

| | |
|---|---|
| Vehicle No. 864 | |
| Remaining life in years[a] | 6 |
| Net realizable value[a] | $26,000 |
| Salvage value[a] | 5,000 |
| Depreciation | 3,170 |
| Operations and maintenance[a] | 6,000 |
| Vehicle No. 876 | |
| Remaining life in years[a] | 1 |
| Net realizable value[a] | $ 7,000 |
| Salvage value[a] | 5,000 |
| Depreciation | 2,000 |
| Operations and maintenance[b] | 9,171 |
| Transfer station amortization[c] | 700 |
| Vehicle operator at $1.85/hr | 3,848 |
| Transfer station maintenance at $1.05/hr | 3,120 |
| Total Annual Transfer Cost | $28,009 |

[a]Estimated.

[b]Based on 10 months of records, includes fuel and tires.

[c]Based on straight line depreciation over 15 years for a cost estimated at $10,900.

# APPENDIX B-IV

## ANNUAL OVERHEAD COSTS

| Budget No. | Item | Cost[a] |
|---|---|---|
| 246 | Utilities | $ 459 |
| 274 | Car fares | 12 |
| 314 | Supplies | 3,584 |
| 325 | Miscellaneous | 26 |
| 423 | Lumber | 24 |
| 259 | Professional services | 589 |
| 359 | Wearing apparel | 1,893 |
| 212 | Building repair | 29 |
| 226 | Electrical | 90 |
| 624 | Office machines | 372 |
| 333 | Lettering | 83 |
| 308 | Drugs | 42 |
| 230 | Equipment repair | 185 |
| 245 | Laundry | 1,726 |
| 257 | Pressing uniforms | 342 |
| 276 | Tool repair | 12 |
| 309 | Diesel fuel | 32 |
| 841 | Supervisor's vehicle | 689 |
| | Amortizing structures[b] | 1,000 |
| | Supervisor's salaries[b] | 8,000 |
| | Total | $19,221 |

[a] Extrapolated from 10 months of records.

[b] Estimated.

# APPENDIX C

## RESIDENTIAL SOLID WASTES ANALYSIS

## BY PHYSICAL SEPARATION

Residential solid wastes were collected from four distinct economic areas of the City. These areas were taken from a map prepared for Technical Services by the City Planner of Johnson City who used an up-to-date census in their preparation. A sample was chosen in each economic area weighted to the total number of units estimated in that area. The total sample of 136 homes was broken down into:

| Economic area annual income | Percent of city population | No. of samples |
|---|---|---|
| 0 - $3000 | 22.2 | 30 |
| $3000 - $6000 | 44.6 | 60 |
| $6000 - $9000 | 19.4 | 26 |
| over $9000 | 14.8 | 20 |

The sample size of 136 homes was chosen to yield a quantity of solid wastes which the study team could sort easily in one day and which would give reliable projections for the solid wastes composition of the entire residential sector of Johnson City. The work of Bell* provided the statistical justification for a sampling ratio of $1.27 \times 10^{-2}$ (population sampled to total population) which allows the sampled composition to be projected to the total population with 97 percent accuracy. This procedure insured that the sample reflected wastes generated during the study week. Further samples are needed to detect seasonal variations.

A city crew and truck collected on Tuesday (the regular collection day) from the sample areas shown in Figures C-1 through C-3. The compactor truck made two trips with small loads to avoid significant compaction. It is felt that for future work it would be acceptable to collect an entire sample of this size in one truck. The sample was mixed and quartered with a front-end loader at the compost plant. It was separated into large cartons and on plastic drop cloths. The first half, third quarter and fourth quarter were separated individually in order to estimate the sample size necessary for future studies in Johnson City with more limited manpower.

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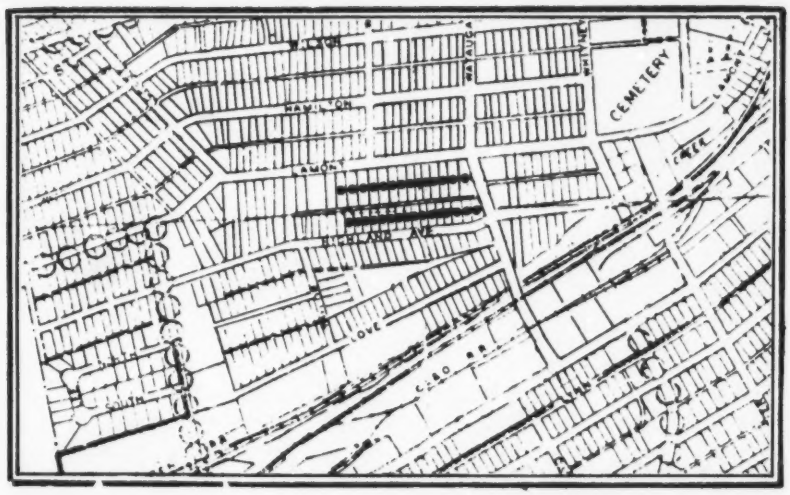
*Bell, J. M. Characteristics of municipal refuse. In Proceedings, National Conference on Solid Waste Research. Chicago, American Public Works Association, 1963, p. 28-38.

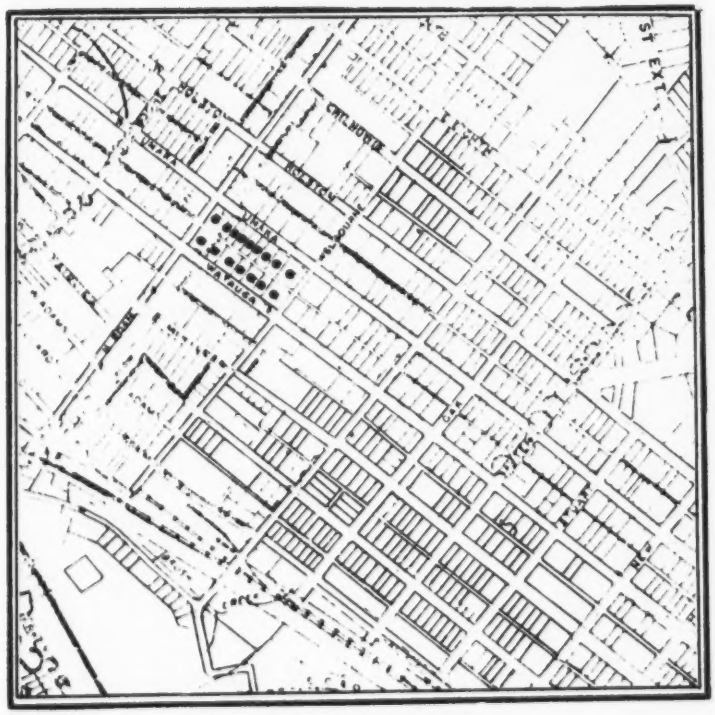
The fourth quarter was separated less carefully than the preceeding fractions. Shovels were used to turn the pile while all large pieces of paper, glass and food wastes were removed, categorized, and weighed. The final pile of fine material was weighed and its composition estimated visually as: 35 percent paper; 45 percent food wastes; 10 percent glass; and, 10 percent metal. The accuracy of these results, as Table C-1 shows, suggests this method might prove sufficient for future separations where time and manpower are limited.

The sample showed two surprising characteristics. The percentage of food wastes was higher than expected, and the total contributions from each residence was lower than expected. The high fraction of food wastes probably resulted from a seasonal reliance on fresh and home-canned rather than pre-packaged foods, and from the small number of garbage grinders in the City. The small quantity of waste from each residence was verified from truck weights and is attributed to active salvage operations, special collections for yard wastes, backyard burning and the fact that some wastes were privately hauled.




Less Than $3,000 Average Income

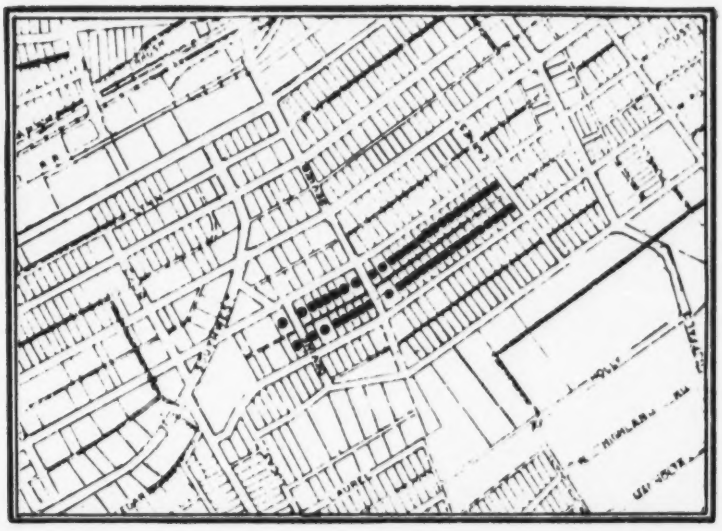
(30 Sample Points)




$3,000 - $6,000 Average Income

(12 Sample Points)

Figure C-1



$3,000 - $6,000 Average Income

(48 Sample Points)

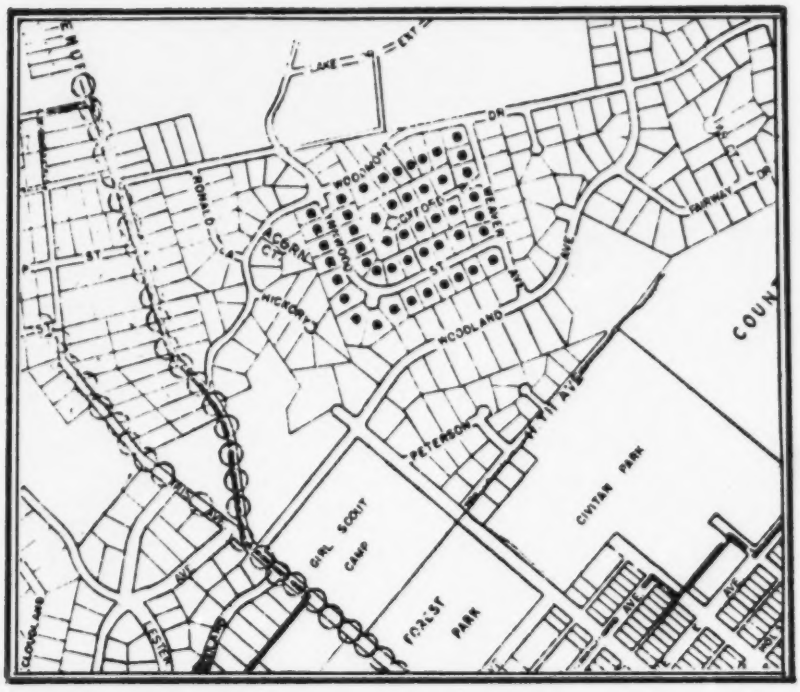
$6,000 - $9,000 Average Income

(26 Sample Points)

Figure C-2

Over $9,000 Average Income

(20 Sample Points)




Over $9,000 Average Income

( Suggested substitute sample area )

Figure C-3

Johnson City, Tennessee October 17, 1967

PHYSICAL SEPARATION OF RESIDENTIAL SOLID WASTE IN POUNDS PER CATEGORY

| Categories | Load: First Half | Third Quarter | Fourth Quarter | | Total |
|---|---|---|---|---|---|
| Food wastes | 583.9 | 211.0 | 147.0 | 95.0[a] | 1036.5 |
| Glass products | 220.5 | 97.5 | 97.0 | 21.1 | 436.1 |
| Metals[b] | 236.5 | 88.0 | 87.0 | 21.5 | 433.0 |
| Cloth & synthetics | 25.5 | 12.5 | 18.0 | | 56.0 |
| Paper products | 900.0 | 420.0 | 397.0 | 73.4 | 1820.4 |
| Plastics | 34.0 | 15.0 | 18.0 | | 67.0 |
| Leather & rubber | 18.5 | 12.0 | 9.5 | | 40.0 |
| Yard wastes | 61.0 | 0 | 2.5 | | 63.5 |
| Wood | 5.5 | 0.5 | 9.5 | 6.5 | 11.5 |
| Brick, rock, dirt, etc. | 15.0 | 8.5 | 15.5 | | 39.0 |
| Totals | 2100.0 | 895.0 | 1008.0 | | 4003.0 |

PHYSICAL SEPARATION OF RESIDENTIAL SOLID WASTE IN PERCENT PER CATEGORY

| | | | | |
|---|---|---|---|---|
| Food wastes | 27.8 | 23.6 | 24.0 | 25.9 |
| Glass products | 10.6 | 10.9 | 11.8 | 10.9 |
| Metals[b] | 11.3 | 9.8 | 10.8 | 10.8 |
| Cloth & synthetics | 1.2 | 1.4 | 1.8 | 1.3 |
| Paper products | 42.9 | 50.3 | 46.7 | 45.5 |
| Plastics | 1.6 | 1.7 | 1.8 | 1.7 |
| Leather & rubber | 0.8 | 1.3 | 0.9 | 1.0 |
| Yard wastes | 2.9 | - | 0.2 | 1.6 |
| Wood | 0.2 | 0.1 | 0.5 | 0.3 |
| Brick, rock, dirt, etc. | 0.7 | 0.9 | 1.5 | 1.0 |

[a]Components of 211.0 lb. special category.

[b]Percent nonferrous metals was very small - not weighed.

TABLE C-1

# APPENDIX D

## COMMERCIAL SOLID WASTE ANALYSIS

| Category | Percent by weight[a] |
|---|---|
| Food wastes | 16 |
| Glass products | 3 |
| Metals | 4 |
| Cloth and synthetics | 1 |
| Paper products | 76 |
| Plastics | -- |
| Leather and rubber | -- |
| Yard wastes | -- |
| Wood | <1 |
| Bricks, rocks, dirt, etc. | <1 |

[a]Estimated visually from bulk containers.

# APPENDIX E

## COMBINED COMMERCIAL AND RESIDENTIAL SOLID WASTE ANALYSIS

| Category | Percent by weight[a] |
|---|---|
| Food wastes | 21.1 |
| Glass products | 7.0 |
| Metals | 7.5 |
| Cloth and synthetics | 1.3 |
| Paper products | 59.8 |
| Plastics | 0.9 |
| Leather and rubber | 0.6 |
| Yard wastes | 0.9 |
| Wood | 0.3 |
| Bricks, rocks, dirt, etc. | 0.6 |

[a]Includes estimated values for commercial wastes.

# APPENDIX F

## APPENDIX F-I

## STUDY SCHEDULE

| Study element | Date conducted (October, 1967) | Men |
|---|---|---|
| Industrial survey | 16, 17, 19, 20 | 1 |
| Commercial survey | 16, 17, 19, 20 | 1 |
| Fly breeding survey | 16 | 2 |
| Compactor truck weighing | 16, 17, 19, 20 | 1 |
| Bulk container truck weighing | 16, 17 | - |
| Storage survey | 17 | 2 |
| Survey of annexable areas | 16, 20 | 2 |
| Clinic survey | 16, 17 | 1 |
| Interview with Wash. Co. Utility Dist. | 17 | 1 |
| Collecting sample for physical separation | 17 | 3 |
| Physical separation | 18 | 8 |

APPENDIX F-II

HOSPITAL SURVEY

Name of the Institution _____

Persons Interviewed _____

_____

Description of Activities (Type of hospital, No. of beds, Cafeteria, No. of residences, etc.)

_____

_____

_____

Types and Quantities of Waste Produced:

Garbage _____

Yard Clippings _____

Clinical & Surgical _____

Rubbish _____

Biopsy _____

Autopsy _____

Collection:

Collection Agency

Disposal Site

General:

Prevalent Contagious Diseases

Other

# APPENDIX F-III

## COMMERCIAL SURVEY

Name of establishment _____ Day & Date _____

Address _____

Solid Wastes

Quantity _____ T./wk _____ CYD./ ____

Composition (est. percent)

Paper _____ Textiles _____

Wood _____ Metal _____

Food _____ Other (specify) _____

Collection

Mode _____

Frequency _____/wk.
s m t w t f s

Collector _____

Disposal Site _____

On-Site Disposal:

Burning _____

Burial _____

Containers

Number _____ _____ _____

Size _____ _____ _____

Notes:

APPENDIX F-IV

INDUSTRIAL SURVEY

Company Name _____ Day & Date _____

Address _____

Type of Industry _____

Employees: Production _____

Total _____

Operations _____ Hrs./Day _____ Hrs./Wk.

Description of Physical Plant (No. and Type and Size of Building, Acreage, Cafeteria...)

_____

_____

_____

SOLID WASTES

| | SOURCES | | | | |
|---|---|---|---|---|---|
| | Office | Shipping | Process | Cafeteria | Other |
| Frequency of Collection | _____ | _____ | _____ | _____ | _____ |
| Wt./ _____ | _____ | _____ | _____ | _____ | _____ |
| CYD./_____ | _____ | _____ | _____ | _____ | _____ |
| Composition* (visual) | _____ | _____ | _____ | _____ | _____ |
| Collector | _____ | _____ | _____ | _____ | _____ |
| Disposal Site | _____ | _____ | _____ | _____ | _____ |

*Paper, Glass, Wood, Metal, Food Wastes ...

Notes:

APPENDIX F-V

CLINIC SURVEY

1. Name of Clinic _____ Date _____

   Address _____

   Person Interviewed _____ Title _____

2. Type of Clinic _____

   Employees: Number Position

   _____ _____

   _____ _____

   _____ _____

   _____ _____

   Patients/Day _____

   Operation (Day/Week) _____

   Specialities of Clinic _____

   Contagious Disease Treated and Frequency _____

   _____

3. Quantity of Solid Waste Per Week _____

   _____

   Type and Composition

   Paper _____ Pathogenic Tissue _____

   Glass _____ Metal _____

   Chemicals _____ Other (specify) _____

   Pathogenic Tissue _____ Other (specify) _____

4. How Stored in Clinic _____

   _____

   How Often are Containers Cleaned _____

   How Stored Outside Clinic _____

   _____

   How Often are Containers Cleaned _____

5. Collection Frequency _____ Per Week
   s m t w t f s

   Collection Agency _____

   _____

   Method _____

   Destination of Refuse _____

   _____